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Dependency of effective climate sensitivity on the parameterization of land evaporation

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Equilibrium and transient responses of climate models to changes in external forcing are defined by equilibrium and effective sensitivities respectively. Published results show that climate models with similar equilibrium sensitivities may have rather different effective sensitivities and vice versa. Reasons for such differences are not well understood.

Here we explore relationship between effective and equilibrium sensitivities for two modifications of a climate model of intermediate complexity (MIT IGSM) employing different land models. One version uses two layer bucket model adopted from the GISS AOGSM (IGSM1a), the other uses Community Land Model version 2 (IGSM2.2). Versions of the IGSM1a and IGSM2.2 with similar equilibrium climate sensitivities exhibit different transient response to an external forcing. In the simulations with an instantaneous doubling of CO_2 concentration IGSM2.2 requires much longer to reach equilibrium especially for high climate sensitivity. Analysis of changes in surface fluxes reviled much smaller rate of an increase in the land evaporation per degree of surface warming in the IGSM2.2 compare to the IGSM1a. While evaporation from land is too small to directly affect surface energy budget in a significant way, smaller rate of the land evaporation response to surface warming leads to the delay in the increase in the atmospheric water vapor. This, in its turn, causes slower warming by reducing incoming longway radiation at the surface. Difference in the evaporation response to warming is explained by the fact that in the CLM land evaporation is parti-

tioned into transpiration, soil and canopy evaporation, while in the GISS scheme only soil evaporation is calculated.

Differences in the response to an external forcing between two versions of the IGSM result in different relationships between equilibrium and effective sensitivities. In the version using two layer surface scheme effective and equilibrium sensitivities are almost identical except for the very high values of sensitivity. In contrast, effective sensitivity of the IGSM2.2 is noticeably smaller than equilibrium sensitivity for values of Seq greater than 5K. Strength of feedbacks at the time of CO_2 doubling in simulations with 1% per year increase in CO_2 concentration is about 80% and 95% percent of their strength at the equilibrium with doubled CO_2 concentration in simulations with the IGSM2 and IGSM1a, respectively.